CHAPTER 14

Graphics Adapters

This chapter presents the requirements and recommendations for graphics adapters.

The key design goal is to ensure that graphics hardware behaves consistently across a wide range of applications, based on the need of the system to provide fast, high-quality graphics rendering.

Requirements for OpenGL support are defined in Chapter 4, “Workstation PC 99.” Requirements for MPEG and DVD playback, video input and capture devices, and display monitors are defined in Chapter 15, “Video and Broadcast Components,” and Chapter 16, “Monitors.”

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System Requirements for Graphics Adapters

This section summarizes the PC 99 system requirements for graphics adapters.

Mobile PC Note

For exceptions and guidelines for the internal display on mobile PCs, see Chapter 6, "Mobile PC 99"; mobile PC exceptions are also summarized as notes in the individual sections of this chapter.

14.1. Graphics adapter uses PCI, AGP, or another high-speed bus

Required for all system types

Recommended: Pipelined Accelerated Graphics Port (AGP) attachment with optional sideband addressing and double-clocked data transfer mode, as defined in *Accelerated Graphics Port Interface Specification*, *Revision 1.0* or later, plus PC 99 requirements defined in "AGP Requirements" later in this chapter.

Note: It is anticipated that AGP, or an integrated graphics subsystem that meets or exceeds AGP performance levels, will be required for all system types in the next version of this design guide.

In all cases, PCI adapters can be used as secondary graphics adapters.

14.2. System provides hardware-accelerated 3-D graphics

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Required	*Recommended*	*Recommended*	*Required*	*Required*

The graphics adapter requirements on PC 99 systems that implement 3-D acceleration are defined in "Hardware Acceleration for 3-D Graphics" later in this chapter.

For most systems, 3-D acceleration is based on Direct3D capabilities provided in the operating system.

Systems designed as Windows NT graphics workstations must provide a 3-D accelerator that supports either OpenGL or Direct3D acceleration. Support for Direct3D on OpenGL accelerators is recommended for Windows NT 5.0. OpenGL support can be implemented under Windows NT as a Mini Client Driver (MCD) or Installable Client Driver (ICD). OpenGL driver support for Windows 98 is optional and can only be implemented as an ICD.

For implementation details for OpenGL, see the Windows 95 DDK and the Windows NT 5.0 DDK.

14.3. System uses WC with higher-performance processors

Required for all system types

Write combining (WC) of successive stores to the frame buffer is a requirement for systems with processors that support write combining.

14.4. Primary graphics adapter works normally with default VGA mode driver

Required for all system types

The default video graphics array (VGA) driver is required for installing the operating system. The primary adapter must support 4-bit planar VGA mode as described in the Windows 95 DDK and the Windows NT 5.0 DDK.

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14.5. Adapter and driver support multiple adapters and multiple monitors

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Required	*Required*	*Recommended*	*Required*	*Required*

System expansion buses that allow graphics adapters such as PCI and AGP can support the simultaneous use of more than one graphics adapter in the system. Each graphics adapter can support one or more attached monitors, but this is not a requirement. Although only a single AGP device can be implemented in a system, multiple-monitor support can be implemented using add-on PCI graphics adapters.

The device drivers for each graphics adapter must provide the required support to allow the presence of multiple adapters and multiple monitors. The hardware and BIOS support consist of Plug and Play-related configuration and resource requirements that ensure automatic support for use of more than one graphics adapter and for simultaneous display on two or more monitors. For details, see "Multiple-Adapter and Multiple-Monitor Support" later in this chapter.

Mobile PC Note

For mobile PCs, multiple adapter support is not required unless the mobile system supports a full docking station. For information, see requirement 6.20, "Mobile system meets Mobile PC 99 requirements for supporting multiple adapters and multiple monitors."

14.6. Adapter supports television output if system does not include large-screen monitor

Recommended for all system types

Recommended: Support both National Television System Committee (NTSC), Phase Alternation Line (PAL) output, or both.

Support for television output is especially recommended for Entertainment PC systems that do not include a large-screen entertainment monitor. The ability to connect to and use a standard NTSC or PAL television as a large display surface is key to the ability to deliver realistic television, movie, and game experiences.

For mobile PCs, television-output capabilities can be used to enable on-screen presentation graphics in the conference room.

The NTSC system must support 640 × 480 at 60 Hz. The PAL system must support 640 × 480, 800 × 600, or both at 50 Hz. For information about the related requirements, see "PC 99 Television Output Requirements" later in this chapter.

The following items are recommended:

- Provide composite, S-Video, and component outputs. Component outputs are especially important in Europe and will become important in North America in the 1999–2000 timeframe.
- A second display controller to drive television output. This allows a separate pixel surface, which is supported under Windows NT and Windows 98. Including a second display controller lets a home PC drive its monitor at 75 Hz for word processing while a DVD movie or broadcast program shows simultaneously on the television at 60 Hz.

  Referring to two display controllers merely indicates functionality. It is not intended to preclude other implementations that achieve the same result. The desired result is two independently timed outputs to different displays.

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Graphics Adapters Basic Features

This section defines basic feature requirements for graphics adapters.

14.7. Adapter meets PC 99 general device requirements

Required for all system types

This includes the requirements for Plug and Play device IDs, automated software-only settings for device configurations, device drivers and Windows-based installation, and icons for external connectors. For information, see "PC 99 General Device Requirements" in Chapter 3, "PC 99 Basic Requirements."

14.8. Screen resolution and local memory capacity meet PC 99 minimum requirements

Required for all system types, with exceptions for mobile PCs

The adapter must support all required resolutions, including:

640 × 480 × [8, 15 or 16, 24 or 32] bpp
800 × 600 × [8, 15 or 16, 24 or 32] bpp
1024 × 768 × [8, 15 or 16] bpp

The following resolutions are recommended:

1024 × 768 × 24 bpp
1280 × 1024 × [8, 15 or 16, 24 or 32] bpp

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It is acceptable to implement either 15-bit or 16-bit color mode, and it is also acceptable to implement either 24-bit or 32-bit color mode. Notice that in the later case, the 32-bit mode is preferred because it provides more spare bits for alpha blending capability.

All PC 99 systems, except Office PC and the Mobile PC built-in graphic subsystem, must provide for rendering buffers up to 800 × 600 × 16-bit bpp (double-buffered), 16-bit Z-buffering, and a 1.25 MB texture cache. This requires an effective memory footprint of approximately 4 MB. For AGP-enabled systems, which store and execute textures directly from AGP system memory, there is no texture cache requirement.

Mobile PC Note

Mobile PC capabilities for external monitor support are also limited to the degree they can be supported by the graphics controller capabilities and frame buffer size. For complete details, see "Mobile PC Graphics Requirements" in Chapter 6, "Mobile PC 99."

Designs for systems that will support Direct3D applications should provide sufficient 3-D texture access to meet the 3-D performance recommendations defined in requirement 14.34, "Hardware meets PC 99 3-D accelerator performance requirements."

Texture compression can provide additional effective texture memory; it also increases the effective memory bandwidth that is available.

14.9. Adapter meets VESA specifications for ergonomic timing rates

Required for all system types, with exceptions for mobile PCs and flat panel desktop displays

Recommended: 85 Hz for 1024 × 768, non-interlaced.

The graphics adapter must support, at a minimum, the 75 Hz ergonomic timings for all resolutions supported by the monitor up to 1024 × 768, as documented in

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the current version of *VESA and Industry Standards and Guidelines for Computer Display Monitor Timing*. Higher timings and resolutions are preferable under standards published by Video Electronics Standards Association (VESA).

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In addition to the standard VESA timings, it is also necessary to support the 59.94 Hz variants of the 60 Hz timings. This is important for smooth frame delivery in TV video applications.

Mobile PC Note

For flat panel displays for desktop or mobile use, it is not necessary to implement refresh rates higher than 60 Hz. For additional exceptions and requirements for mobile PC systems, see "Mobile PC Graphics Requirements" in Chapter 6, "Mobile PC 99."

When the user selects 1024 × 768 resolution, the graphics adapter must default to a non-interlaced refresh rate. A graphics adapter can default to 1024 × 768 interlaced mode in either of the following situations:

- The attached monitor is not DDC-compatible and the user has not selected a monitor type in the display control panel.
- The monitor does not support 1024 × 768 non-interlaced mode, as determined from the Extended Display Identification Data (EDID) or registry settings.

14.10. All supported color depths are enumerated

Required for all system types

The driver must enumerate all modes supported so that applications can choose their preferred color depth. The driver must comply with the following guidelines for enumeration:

- For 16 bpp, either the 5:5:5, 5:6:5, or both modes must be supported.
- If only the 5:5:5 mode is supported, the driver must also enumerate this as 16-bpp mode. This is required because some applications only look for 16-bpp support and will run in 8-bit mode if they fail to find a 16-bit mode.
- If both 5:5:5 and 5:6:5 modes are supported, both modes must be enumerated.

For each color depth supported, color ordering must be implemented as shown in the following list. Color ordering is shown in the following table from the most-significant bit (MSB) to the least-significant bit (LSB.)

Mode	Color ordering
15 bpp	1 undefined, 5 red, 5 green, 5 blue (URRR RRGG GGGB BBBB)
16 bpp	5 red, 6 green, 5 blue (RRR RRGGG GGGB BBBB)
24 bpp	8 red, 8 green, 8 blue (RRRR RRRR GGGG GGGG BBBB BBBB)
32 bpp	8 alpha, 8 red, 8 green, 8 blue (AAAA AAAA RRRR RRRR GGGG GGGG BBBB BBBB)

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14.11. Graphics operations use relocatable registers only

Required for all system types

VGA registers must not be used to perform graphics operations such as bit blting, palette setting, and pointer movement. The registers used for these graphics operations can be either I/O locations or memory-mapped locations, but must be relocatable. Normal system operation should never require use of base VGA registers, except for system startup and mode setting.

DirectDraw and Direct3D functionality must be independent of VGA. This means that graphics require VGA only for initialization.

14.12. Adapter supports downloadable RAMDAC entries for integrated color management

Required for all system types

For graphics adapters that support 24-bit or higher displays, downloadable RAM digital-to-analog converter (RAMDAC) entries should be included to perform gamma correction in hardware. This capability supports the related requirement to use VGA only for system initialization defined in requirement 14.11, "Graphics operations use relocatable registers only."

Integrated color management (ICM) uses this capability to ensure that gamma is correct in the monitor and to allow game applications to switch palettes. This capability also supports transition effects in Internet Explorer 4.0 and other applications.

14.13. Adapter supports DDC monitor detection

Required for all system types, with exceptions for mobile PCs

This requirement is based on the *Display Data Channel Standard, Version 3.0* (DDC), which defines the communication channel between the display and host system. The software can use this information to properly manage output to the various displays and to prevent the disabling of television output if no monitor is attached.

Mobile PC Note

Mobile systems are not required to support DDC monitor detection of the display if the display is permanently attached and connected using an internal interface. However, such systems must support DDC for the external monitor interface port.

Hardware Acceleration for Video Playback

This section presents the video playback requirements for graphics adapters created for systems that support TV or DVD video playback.

14.14. Hardware supports video overlay surface with scaling

Required for systems that support TV or DVD video playback, with exceptions for mobile PCs

It is envisioned that the overlay surface will be implemented using one of the required YUV formats. The graphics adapter must be able to support a minimum of one off-screen video overlay surface that has following characteristics:

- **14.14.1 Size.** Support for 720 × 576 or larger.

  To support the HD0 formats for DTV—notably 720p24—it is required to support 1280 × 720 on the Entertainment PC.

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- **14.14.2 Screen Resolutions.** The video overlay must be fully operative at a minimum screen resolution of 1024 × 768 at 60 Hz and color depths of 8 bpp and 16 bpp.

  Recommended: Full support at 1280 × 1024, with color depths of 8, 16, 24, and 32 bpp.

Mobile PC Note

For mobile systems, screen resolutions are defined in Chapter 6, "Mobile PC 99."

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- **14.14.3 Color formats.** The required formats must include the following:
  - YUV 4:2:2 YUY2: A packed-pixel byte stream for every pixel in the order of Y1, U, Y2, V is required in both the primary and secondary overlay surfaces.

    Recommended: Support for YUV 4:2:2 UYVY: A packed-pixel byte stream for every pixel in the order of U, Y1, V, Y2 is recommended in both the primary and secondary overlay surfaces.
  - YUV 4:2:0 YV12: A system-board byte stream for the entire plane in the order of Y plane, V plane, U plane is required in the secondary overlay surface when double-buffering is supported.

    If double buffering is not supported, YV12 support must be provided in the primary overlay surface.

    Support of the YUV 4:2:0 format is not a requirement if the graphics chip supports on-chip MPEG decoding (more than 75 percent hardware solution). In this situation, YUV 4:2:0 capability is only a recommendation, although it is still highly advised to support software MPEG decoding for secondary video windows.

Mobile PC Note

Mobile PCs that implement TV or DVD video playback features are required to support at least one of these color formats.

The YUV color space and intensity range are defined by the ITU-R BT.601-4 standard (previously called CCIR-601), where U is CB and V is CR. These formats use less memory while maintaining high quality, and YUV is the native format for many image and video compression standards.

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- **14.14.4 Scaling.** Upscaling or downscaling to any size window. The higher quality video scaling can occur anywhere between the video input to the chip, on the AGP, PCI, or side port, and the video appearing on the screen.

  Video scaling must be implemented using the existing DirectDraw and DirectShow APIs.

  For PCs to effectively compete with dedicated consumer electronics video devices, it is necessary to raise the quality of video scaling on the PC. Specifying scaling quality is hard because of the difficulty of quantifying viewer-perceived video quality. In the absence of anything better, guidelines for the quality of the video filter used in the resizing operations are specified for each system type in the following lists.

  Scaling requirements for video-enabled Office PC or Mobile PC systems:
  - Hardware scaling is not a requirement, but bi-linear scaling (two taps vertically and two taps horizontally) is recommended. However, considerable user and marketplace benefits can be gained by implementing the video playback requirements defined for Entertainment PC systems.

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- Any hardware scaling engine present on a non-DTV–enabled Office PC is required to be able to accept a standard definition video input (480i or 576i), such as might come from a DVD or NTSC source. For a DTV-enabled Office PC, the requirement is that the scaling engine, if one is present, must be able to accept an input with a rate of 480p60 (720 horizontal pixels) and 720p24 (1280 horizontal pixels).

Scaling requirements for video-enabled Consumer PC system:

- The minimum requirement is to use bi-linear scaling; a filter with two vertical taps and two horizontal taps is required. Recommended: a minimum of three taps vertically and four taps horizontally be implemented and, ideally, four or five vertical and seven or eight horizontal taps.
- The ability to shrink or zoom by a variable factor of up to 8:1 in one-pixel increments is required.
- Image quality should not be perceptibly degraded when shrinking by factors up to 2:1. Some image degradation is acceptable for the larger shrink ratios, although market acceptance of the product will suffer if image quality is excessively degraded.
- The scaling engine on a non-DTV–enabled Consumer PC must be able to accept a standard definition video input (480i or 576i), such as input that might come from a DVD or NTSC source. The scaling engine must be able to accept an input with a rate of 480p60 (720 horizontal pixels) and 720p24 (1280 horizontal pixels).
- Upscaling must be implemented in hardware. Downscaling should be implemented in hardware. Future versions of this design guide are likely to exclude the practice of being able to downscale the driver.

Scaling requirements for Entertainment PC systems:

- The scaling filter (interpolator) is required to implement a minimum of three taps vertically and four taps horizontally. Recommended: a minimum of three taps vertically and four taps horizontally be implemented and, ideally, four or five vertical and seven or eight horizontal taps.
- The ability to shrink or zoom by a variable factor of up to 8:1 in one-pixel increments and the ability to shrink by a variable factor of up to 16:1 in one-pixel increments is required.
- Image quality should not be perceptible degraded when shrinking by factors up to 4:1. Image degradation is acceptable for the larger shrink ratios, although market acceptance of the product will suffer if image quality is excessively degraded.
- The scaling engine on a non-DTV–enabled Consumer PC is required to be able to accept a standard input with a rate of 480p60 (720 horizontal pixels) and 720p24 (1280 horizontal pixels).
- Both upscaling and downscaling must be implemented in hardware.

The term “tap” is defined here as the number of input pixels that contribute to the building of each output pixel. A bi-linear filter is two taps, and a three tap filter is a filter better than bi-linear. For filter designs employing three or more taps, it is desirable to use a “windowed sinx/x” function. However, the “windowing” process needs particular attention, especially when small numbers of taps are used to achieve the best subjective picture quality.

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To allow optimization, it is sensible for filter coefficients to be stored in a look-up table with values that are downloadable from the driver. For shrinks greater than a 2:1 ratio, larger numbers of taps are needed.

An example would be putting shrink factors, such as a halving factor in series with the variable shrink factor specified earlier. When doing shrinks, great care needs to be taken with the filter coefficients to minimize spatial aliasing. High-frequency components in the source should ideally be attenuated by either pre-filtering or adjusting the interpolation filter characteristics.

When scaling 4:2:2 or 4:2:0 YUV video, scaling is only acceptable with two-pixel granularity. A method must be employed to present this as one-pixel granularity on window size because users will resize windows with one-pixel granularity. One acceptable method would be to crop a one-pixel strip from the resized video where necessary.

Recommended: Additional independent and resizable overlays for support of picture-in-picture (PIP) video features and multiple video conferencing windows are recommended on all system types.

Future versions of these guidelines are likely to specify higher quality scaling. A particular area of focus is likely to be the quality of back-end upscalers, which will need to increase. An example is an increase to a three-tap by five-tap interpolator for all video-enabled desktop PCs.

14.15. Hardware supports VGA destination color keying for video rectangle

Required for systems that support TV or DVD video playback

This is a requirement for video overlays. The hardware must be capable of independently controlling the VGA pixels for compositing the video plane under the VGA plane. This VGA destination color keying must function in all video modes using either or both of the following:

- A specific color/color range, for example, on 4-bit, 8-bit, 15-bit, and 24-bit SVGA modes
- Additional alpha blending bits in the color plane bits on 16-bit and 32-bit SVGA modes

Color keying the VGA allows certain VGA pixels to be replaced by the underlying video pixels on a pixel-by-pixel basis. This feature enables VGA video overlays, controls, Windows pop-up menus, dialog boxes, and so on, and it allows for irregular-shaped graphics compositing. Color keying must work simultaneously with any vertical/horizontal scaling active for the underlying video.

14.16. Hardware supports alpha blending of graphics and video

Required for systems that support TV of DVD video playback, with exceptions for mobile PCs

The hardware must support alpha blending for DVD-Subpicture and the user interface (UI) for data-enhanced television.

The DVD-Subpicture stream has 4 bits of alpha information per pixel that indicate how the subpicture should be composited with the main picture. In the future, data-enhanced television streams will also require alpha-composited UI functionality with 8-bit control. With 8 bits, the translucency can be faded in and out, which is important to the creative community. This type of control is currently provided by set-top boxes such as WebTV® service.

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In color modes that support alpha blending, such as ARGB8888, the blend level is controlled on a per-pixel basis. Color modes that do not support alpha blending, such as RGB 565, should allow an overall constant alpha blend value for the overlay.

A minimum of 4 bits of alpha blending must be provided in any secondary overlay surface when in 32-bit mode, such as ARGB8888. In other color modes, it is acceptable within the 1999–2000 timeframe to synthesize the effect within the secondary overlay surface. This can be done using methods such as screen-door dithering using the overlay color key or 1-bit alpha control. Full 8-bit alpha control is defined as a 256-level linear translucency state from 0 percent (value of 0) to 100 percent (value of 255). When fully implemented, linearity should be monotonic with an accuracy within 0.5 bits.

Whatever alpha-blending scheme is implemented, the driver should present it as an 8-bit control.

It is likely that future versions of this guide will require full 8-bit alpha within any secondary overlay surface.

14.17. Video port meets PC 99 specifications if present on graphics adapter

Required

Support for a video side port is recommended. This requirement applies to all graphics adapters that use a video port connection or that enable end users to make such a connection to a video device. The video port is a dedicated connection between video devices, such as the graphics adapter and an MPEG-2, NTSC, or PAL decoder. A video port can be implemented as a hard-wired connection on the same board as the graphics adapter or implemented between separate devices using a cable connection.

Video side ports that have host port or bi-directional capability provide a useful way to attach additional functionality to the graphics chip. In addition to the obvious case of NTSC/PAL decoders, this is useful for optional functions and for functions that would not fit on the silicon of the graphics, such as MPEG decoders and high quality de-interlacers.

It is expected that most implementations of graphics adapters will have a single MPEG decoder on the graphics adapter. Providing a side port connector on the card allows addition of other decoders.

For a graphics adapter that includes a video port, the following requirements must be met:

- **14.17.1 Autoflipping.** The video port must support automated overlay and video port buffer flip on video port vertical synchronization (Vsync).
- **14.17.2 IRQ.** The video port must generate an IRQ when Vsync occurs. The kernel-mode video transport component of DirectDraw version 5.0 and later can use this IRQ to perform autoflips. This capability allows fields to be skipped by the video port and also prevents an irregular synchronization from overwriting its buffers. This also enables capture of vertical blanking interval (VBI) and video port data.

  Mobile PC Note

  This IRQ is not required for mobile PCs.
- **14.17.3 Driver.** The driver must support DirectDraw Video Port Extension (VPE), which provides a key element of video playback support in DirectX

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5.0. This support must be incorporated to ensure that the graphics adapter and video port take advantage of VPE capabilities in the operating system.

For information about implementing DirectX support, see the Windows NT 5.0 DDK. See also the white paper on DirectDraw VPE and kernel-mode video transport at http://www.microsoft.com/hwdev/devdes/vpe.htm.

For additional requirements related to implementing video ports, see "System Requirements for Video and Broadcast Components" in Chapter 15, "Video and Broadcast Components."

Recommended: The following guidelines for video ports are recommended to support high-quality TV or DVD video playback:

- **Maximum height.** The graphics adapter should support a register that limits the maximum height of the field that gets written into memory.
- **Separate pitch and start addresses.** The overlay and the video port should support separate pitch and start addresses. This allows the bob algorithm to be used while the video is interleaved, which makes switching between bob and weave modes possible.

14.18. Hardware supports MPEG-2 motion compensation acceleration

Recommended

For products that use MPEG-2 software decoders, MPEG-2 motion compensation acceleration is recommended.

Specifically, this recommendation refers to, but is not limited to, the following:

- Motion compensation of YUV 4:2:0 planar surfaces (versus YUV 4:2:2 packed pixel surfaces) to decrease system memory bandwidth requirements
- Full-precision motion compensation (for example, use 9 bits for an 8-bit signed error term) to prevent degradation of video quality
- Bus mastering of error terms, and vectors to and from AGP memory (versus system memory), to increase memory bandwidth and CPU cache efficiencies

For more guidelines, see "MPEG-2 Video Playback Requirements" in Chapter 15, "Video and Broadcast Components."

14.19. Hardware supports scanning at the same frequency as the incoming video

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*

Frames must not be dropped or repeated for synchronization any more frequently than once every 60 seconds when there is a stable video source. It must be possible to set the refresh rate on the card to be the same as the video being displayed in the primary window. If the video is 59.94 Hz, then the PC refresh rate should be 59.94 Hz +/–0.025 percent. Trying to use a 60 Hz rate when the source video is 59.94 Hz is not acceptable and will cause a "jump" every 17 seconds.

Note: PAL requirements will be addressed in a future document.

Mobile PC Note

The 59.94 Hz requirement does not apply to LCD screen devices for the 1999–2000 time frame.

An effective way to achieve this is with some form of genlocking using a phased-locked loop with a time constant of many seconds to avoid problems with noisy

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signals and changing television channels. When the source is or has been unstable or if the source has been changed, then greater frame dropping or repeating is allowed for the first three minutes after the source becomes stable.

It is recognized that there is an inconsistency with VESA specifications for ergonomic timing rates (VESA timings don't currently include 59.94 Hz). Support of the 59.94 Hz variant of the specified 60 Hz VESA timing is essential for TV video.

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As an alternative to providing the ability to scan at the same frequency as the incoming video, it is possible to use motion vector-steered temporal rate conversion. In the long term, this is a very good solution to CRT displays. However, solutions able to meet the necessary video quality requirements at economical price points are likely to be rare in the 1999–2000 time frame.

Multiple-Adapter and Multiple-Monitor Support

This section defines the requirements for ensuring system support for multiple adapters and multiple monitors. This support ensures that if the user adds a second adapter, resources will automatically be available and the operating system can automatically manage multiple display adapters.

The actual implementation a user might employ could be one of the following:

- Multiple adapters added to the PC system
- A single adapter with a single controller supporting two monitors
- A single adapter with multiple controllers supporting multiple monitors
- Any combination of these scenarios

The support in both Windows and Windows NT requires multiple-adapter/ multiple-monitor compatibility in the BIOS plus the graphics adapter and its driver. This support also requires allowing any secondary graphics adapters to be enabled in VGA mode, thus requiring that VGA for the previous adapter be temporarily disabled.

With this support, a single adapter that supports multiple monitors can display independent screen images. The operating system support therefore also assumes that the different displays might have differing X,Y resolutions, color depths, refresh rates, and display capabilities.

For technical details about implementing driver support for multiple adapters and multiple monitors, see the Windows NT 5.0 DDK and the Windows 98 DDK.

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14.20. Extended resources can be dynamically relocated after system boot

Required

To ensure Plug and Play for multiple-adapter/multiple-monitor capabilities, all non-VGA standard display resources (also known as extended resources, such as register sets and so on) must be capable of being dynamically relocated after system boot.

This is an extension of requirement 14.11, “Graphics operations use relocatable registers only,” plus the requirements defined in “General Plug and Play Requirements” later in this chapter.

14.21. VGA resources can be disabled by software

Required

A means must be provided to allow a driver to disable its adapter from decoding standard VGA addresses to ensure that the adapter is independent of all other graphics adapters in the system. The adapter must remain fully functional without the VGA addresses. See also requirement 14.11, “Graphics operations use relocatable registers only.”

Hardware Acceleration for 2-D Graphics

This section summarizes guidelines related to 2-D DirectDraw graphics features, which can be implemented as hardware acceleration features.

All PC 99 systems require hardware acceleration for 2-D graphics. Robust DirectDraw support is also required to allow 3-D hardware accelerators to take full advantage of the DirectX architecture.

14.22. Frame buffer can be accessed directly by applications

Required for all system types

The visible frame buffers must be accessible. It must be possible for applications to perform direct frame buffer accesses at any time, even while asynchronous accelerator operations are being executed. Without this capability, drivers cannot support DirectDraw or Direct3D on Windows NT, and operations on Windows 98 will not be fully robust.

Some hardware keeps the information in its frame buffers in a format that does not correspond to the linear format standard in DirectDraw, such as tiling the pixels to exploit the 2-D coherence of image data. If this is the case, the hardware must perform translations so that DirectDraw surfaces being accessed directly appear linear. The hardware performing this translation might be a limited resource, but it must be able to perform translations on at least seven DirectDraw surfaces simultaneously. Support for eight or more surfaces is recommended.

14.23. Adapter and driver support linear-mapped, low-resolution modes

Required for all system types

All graphics adapters currently support linear-mapped low-resolution modes, with minimal driver work needed to support this requirement. Decreasing the size of the frame buffer decreases the average polygon size and increases the frame rate for a given scene. These additional modes provide support software rendering for games and software Direct3D.

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If low-resolution support is implemented in the hardware, the following low-resolution modes are required:

320 × 200 × 16 bpp	320 × 240 × 16 bpp	640 × 400 × 16 bpp
320 × 200 × 8 bpp	320 × 240 × 8 bpp	640 × 400 × 8 bpp

The following low-resolution modes are recommended:

400 × 300 × 16 bpp	512 × 384 × 16 bpp
400 × 300 × 8 bpp	512 × 384 × 8 bpp

Note: In Windows 98, low-resolution capabilities must not be defined in the registry so that they do not appear in the display control panel. In Windows NT, the control panel automatically filters out these modes.

14.24. Hardware supports transparent blter

Required for all system types

There is no restriction on source size. A transparent blter can perform a blt with a source key transparent color. This assumes that the blter is asynchronous with the host processor.

14.25. Hardware provides support to prevent tearing

Required for all system types

This must be performed in synchronization with the VBI.

The hardware must support a mechanism for preventing visible artifacts such as “tearing.” The mechanism for doing this is at the discretion of the hardware designer, but it should support tear-free capabilities for both full-screen and non-occluded windowed applications.

Blts must be performed in synchronization with the vertical scan line to avoid tearing. The ability to read the current scan line supports blting or writing to the screen without tearing. In some contexts, such as video playback, this support eliminates the need for the secondary overlay buffer.

For information about the upper limits of resolution to be supported, see requirement 14.8, “Screen resolution and local memory capacity meet PC 99 minimum requirements.”

14.26. Hardware supports programmable blter stride

Required for all system types

This is required as part of the support for textures. A programmable blter stride ensures that Windows can use linear memory. A fixed stride forces Windows to use rectangular memory management, with all the related inefficiencies. It must be possible to specify different strides for the source and destination on blts.

Hardware Acceleration for 3-D Graphics

This section summarizes guidelines related to Microsoft Direct3D technologies that can be implemented as hardware acceleration features. Supporting the items in this section can result in improved performance and improved memory use.

Support for 3-D graphics is required by mainstream business applications plus educational, entertainment, and other applications including the Internet Explorer shell for both Windows 98 and Windows NT 5.0.

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All systems except Office PC and mobile PC systems are required to support 3-D acceleration in the graphics subsystem. Each entry in this section indicates by system type whether a particular feature must be implemented if the graphics adapter includes 3-D support.

Mobile PC Note

For exceptions and requirements for mobile PCs that implement 3-D hardware acceleration, see "Mobile PC Graphics Requirements" in Chapter 6, "Mobile PC 99."

14.27. Hardware supports PC 99-required RGB rasterization

Required for all system types, with exceptions for mobile PCs

In RGB mode under Direct3D, shading across a surface is accomplished by independently interpolating all color components. The following capabilities are required for red-green-blue (RGB) rasterization:

- **14.27.1 Basic 3-D requirements.** To meet basic 3-D requirements, the adapter and driver must do the following:
  - Support 800 × 600 × 16 bpp, double buffered, with 16-bit Z buffer at 75 Hz in full-screen, 3-D graphics mode
  - Make all required features available at the same time; for example, it is not acceptable to turn off specular highlights in order to enable fog
  - Conform to Direct3D rasterization rules
- **14.27.2 Textures.** These include the following:
  - MIP-mapped textures
  - Bilinear or better filtered textures (rather than point-sampled), with perspective correction
- **14.27.3 Alpha blending.** Source alpha blending, and destination alpha blending is recommended. The following modes are defined for Direct3D in the DirectX 5.0 DDK:

Required	Recommended
D3DBLEND_DESTCOLOR	D3DBLEND_BOTHINVSRCALPHA
D3DBLEND_INVDESTCOLOR	D3DBLEND_BOTHSRCALPHA
D3DBLEND_INVSRCALPHA	D3DBLEND_DESTALPHA
D3DBLEND_INVSRCCOLOR	D3DBLEND_INVDESTALPHA
D3DBLEND_ONE	D3DBLEND_SRCALPHASAT
D3DBLEND_SRCALPHA	
D3DBLEND_SRCCOLOR	
D3DBLEND_ZERO	

For source RGB alpha blending, transparent primitives are blended with the background, but the background transparency is not updated. This method provides good visual accuracy if there are not too many overlapping transparent objects.

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- **14.27.4 Lighting and fogging.** These requirements include the following:
  - Flat and Gouraud shading.
  - Depth-based (Z-based) fog of an arbitrary color, calculated on a per-vertex basis. Depth is defined as distance perpendicular to the screen.
  - Specular highlighting.

The Direct3D reference rasterizer provided in DirectX 5.0 and later supports all of these capabilities.

There is no requirement for edge anti-aliasing. See the following recommendation.

14.28. Hardware supports recommended RGB rasterization features

Recommended for all system types, with exceptions for mobile PCs

The recommended RGB rasterization features include the following:

- Range-based and table-based fog
- Hardware support for triangle strips and fans
- Sort independent edge anti-aliasing
- Precision line drawing (Bresenham line drawing algorithm recommended)

14.29. Hardware supports multi-texturing

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Recommended	*Recommended*	*Recommended*	*Required*	*Required*

Multi-texturing hardware can apply multiple textures to a polygon. The most common application of multi-texturing is with map-based techniques for diffuse lighting and specular reflections.

Implementing this capability requires supporting two or more sets of independent texture coordinates. It is recommended that hardware supports combining at least two textures in a single pass.

The following texture combination operations are required:

- MODULATERGB: Component-wise multiplication of both texture colors.
- MODULATELPHA: Multiply colors of one texture by the alpha of the other.
- ADD: Component-wise addition of both textures.
- BLEND: Linear combination of textures weighted by a scalar specified in a register or in a polygon alpha.

Multi-texturing is used to compute the texture value that participates in the pixel pipeline implemented in Direct3D in DirectX 5.0. It is independent of the alpha blending stage in a previous version of Direct3D.

This technique should work in combination with fogging and alpha blending, but it need not operate at the same time as other advanced filtering.

For more information, see the paper on multi-texturing and DirectX available on the web site at http://www.microsoft.com/hwdev/devdes/.

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14.30. Hardware supports texture formats

Required for all system types, with exceptions for mobile PCs

Hardware that implements 3-D acceleration must support palletized textures. Pallet entries use the corresponding nonpalletized formats shown in the following table.

Required	Recommended
8-bit palletized	4-bit palletized
1:5:5:5 ARGB	8:8:8:8 ARGB
4:4:4:4 ARGB	0:5:6:5 ARGB
	4:2:2 YUV

Mobile PC Note

Palletized texture formats are not required for mobile PCs.

14.31. Hardware complies with texture size limitations

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Required	*Recommended*	*Recommended*	*Required*	*Required*

MIP mapping requires that textures of size 1 × 1 be supported. To meet PC 99 requirements, a 3-D accelerator must support this lower limit on texture size.

The texture units must support square and non-square power-of-two textures ($2^n \times 2^m$) up to 256 × 256.

Recommended: The texture unit should support non-power-of-two width and height. This enables the texture mapping unit to be used to emulate blts. Also, it is recommended that the texture unit support an upper limit of 2048 × 2048 rather than the required 256 × 256.

14.32. Hardware supports destination RGB alpha blending

Recommended for all system types

For destination RGB alpha blending, primitives are blended with the background, updating not only the colors in the frame buffer but also a cumulative transparency that can affect the rendering of subsequent primitives.

See the list of required and recommended alpha blending modes as defined for Direct3D in requirement 14.27, “Hardware supports PC 99-required RGB rasterization.”

14.33. Hardware supports Z comparison modes and Direct3D-compatible formats

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Recommended	*Recommended*	*Recommended*	*Required*	*Required*

The 3-D hardware should support 16-bit minimum, unsigned, lockable Z buffer format and all Z comparison modes.

Hardware that supports Z buffering must support clearing of the Z buffer through the DirectDraw depth-fill blt mechanism. However, DirectX 5.0 enables Z buffers to be cleared at the same time as destination surfaces. It is recommended that hardware support simultaneous clearing of color and Z buffers using the DirectX 5.0 mechanism.

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14.34. Hardware meets PC 99 3-D accelerator performance requirements

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Recommended	*Recommended*	*Recommended*	*Required*	*Required*

The 3-D rendering subsystem should have triangle setup capability implemented in hardware that is capable of processing triangles at a sustained rate in excess of 1 million triangles per second.

Each triangle is assumed to be 1 visible pixel in area, front facing, textured, and composed of three vertices, where each vertex contains a diffuse and specular color component. Rendering conditions should be 16 bpp, bilinear textured, Z buffered, and alpha blended. Triangles should be ordered such that the Z check always passes (the current triangle is in front of all previously rendered triangles).

The 3-D rendering subsystem should be capable of filling triangles at a sustained rate in excess of 40 million pixels per second. Each triangle is assumed to be 10,000 visible pixels in area, with the same attributes as described for triangle setup in the previous paragraph. Rendering conditions are also the same as for triangle setup. Supporting 60 million pixels per second is recommended.

Television Output Requirements

This section summarizes the key design issues and requirements for television output capabilities, which are recommended for all PC 99 system types, particularly any Entertainment PC system that does not include a large-screen entertainment monitor.

The required support allows an NTSC or PAL television to be used as a primary or secondary display surface for the Windows operating system and for Windows-based applications. Such a display surface allows more realistic game, video, and multimedia experiences for users who want to use a large-screen television that they already own.

With built-in operating system support, using a separate television resolution display controller for driving the NTSC encoder, which is typically sited on the same graphics adapter, has the following advantages:

- Provides a larger pixel working area.
- Ensures that the PC can be used in one room with a monitor running at 75 Hz for an application such as word processing or games, while it simultaneously drives a television at 60 Hz in another room to show a DVD movie or television program.
- Provides support that is ideal for editing home videos, allowing the user to view the content and the edit time lines simultaneously.
- Eliminates the need for the user to continuously change the display resolution between the high-resolution, high-refresh rate needed for PC applications and the low-resolution, television-resolution mode.
- Eliminates the PC monitor flicker that occurs if the monitor is driven by the same display controller as the television.

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If television output capabilities are provided in a PC 99 system, support is required for either NTSC or PAL standards. NTSC refers to the television standards first developed in the United States and used in Canada, Japan, and Mexico. PAL refers to the television standards first developed in Germany and used in Austria, Belgium Brazil, Denmark, Finland, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom.

For more information about world television standards, see the web site at http://www.bbc.co.uk/aberdeen/eng_info/.

Note: The requirements in this section apply only if the television output capability is present on a PC 99 system or on a graphics adapter that supports television output capabilities. Some television output capabilities listed in this section are required only for Entertainment PC systems.

14.35. Adapter supports both NTSC and PAL output

Recommended for all system types

The television output adapter should support both output standards. If NTSC is supported, then the NTSC system must support 640 × 480 at 60 Hz. If PAL is supported, then the PAL system must support 640 × 480, 800 × 600, or both at 50 Hz.

Whether either or both output standards are supported, software must be capable of independently enabling and disabling television and VGA output.

Note: For NTSC, the 60-Hz mode described in this section is actually 59.94 Hz.

14.36. Default boot mode supports appropriate locale

Required for all system types

If television output capability is present on a PC 99 system, the system and the graphics adapter must enable television output automatically as the primary display if a VGA monitor is not attached. The system must default to modes compatible with television output in the geographic region for which the adapter was localized. NTSC adapters should default to 60-Hz modes; PAL adapters should default to 50-Hz modes. Ideally, an adapter would support both modes and provide a safe means for the default selection to be changed by a user.

Mobile PC Note

For mobile PCs, it is acceptable for television output to be enabled manually.

14.37. Adapter supports underscan scaling

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Required	*Recommended*	*Recommended*	*Recommended*	*Required*

For Consumer PC and Entertainment PC systems, the television output adapter must be able to correct horizontal and vertical overscan using hardware scaling. This allows 640 × 480 resolution modes to fit onto NTSC displays and 800 × 600 resolution modes to fit onto PAL displays.

Driver software must be capable of enabling and disabling scaling and also of adjusting scaling for compatibility with a variety of television monitors. As television monitors age, overscan reduces, so less scaling is required.

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14.38. Adapter supports flicker filter

Required for all system types, with exceptions for mobile PCs

The television output adapter must use multi-line (3-tap minimum) hardware filtering techniques for flicker reduction. Enable, disable, and adjust capabilities for the flicker filter must be software controllable. Also, overscan should be software-enabled when the PC is playing full-screen video.

Mobile PC Note

For mobile PCs, the television output adapter must use 2-tap minimum hardware filtering techniques or better.

14.39. Adapter provides proper termination

Required

Proper termination is required so that optimal picture quality from any connector does not require displays to be attached to other connectors. For example, a VGA monitor must not be required in order for the S-Video output to appear properly.

14.40. Adapter supports composite video and S-Video connectors

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*

Support for both composite video and S-Video is required for Entertainment PCs and is recommended for other system types.

Compared to composite video, S-Video dramatically improves the picture quality of the NTSC or PAL scan converter. This standard is designed to reduce cross talk between chrominance and luminance signals, and to increase the luminance bandwidth capability of the television. A further increase in quality is obtained by using component video, which is common in Europe and will become so in North America.

For information about these standards, see the web site available at http://www.bbc.co.uk/aberdeen/eng_info/.

14.41. Adapter with television output supports both VGA and television output

Required for all system types

In addition to television output, the PC 99 system must also support VGA output to ensure that users with large-screen VGA monitors can use this output capability.

It is recommended that the adapter supports the following:

- Simultaneous output to VGA monitor and television.
- Two display controllers or an implementation that provides the desired result of two independently timed outputs to different monitors.

  With a single controller, both the monitor and television must use a 60 Hz, low-resolution format; which is not desirable.

14.42. Software supports positioning

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Required	*Recommended*	*Recommended*	*Recommended*	*Required*

Software must be able to program the television output hardware to position the television image in increments of 4 pixels horizontally and 4 scan lines vertically.

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14.43. Software supports detection of television connection

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Required	*Recommended*	*Recommended*	*Recommended*	*Required*

For Consumer PC and Entertainment PC systems, software must be able to detect whether a television is attached to S-Video or composite output connectors. Detection of a VGA monitor is based on requirement 14.13, “Adapters supports DDC monitor detection.”

Detection of a television connection is required to allow the operating system and graphics drivers to correctly support display output during the startup sequence (for example, determining what resolution and refresh rate to use) and to allow applications to adjust their user interfaces appropriately to the screen capabilities.

14.44. Analog video outputs, such as NTSC, have copy protection on DVD-enabled platforms

Required for all system types

The use of an appropriate copy protection system is necessary to stop DVD disks from being played on the PC and then recorded on a VCR. Details for MacroVision protection for DVD are available at http://www.macrovision.com.

PC 99 Design for Graphics Adapters

This section summarizes requirements related to the PC 99 design initiatives defined in Part 1 of this guide.

Plug and Play and Bus Design for Graphics Adapters

The items in this section summarize requirements for Plug and Play and other resource- and bus-related capabilities. The specifications in this section are required for all PC 99 systems.

See also requirement 14.11, “Graphics operations use relocatable registers only.”

General Plug and Play Requirements

The requirements in this section ensure easy configuration.

14.45. Each device has a Plug and Play device ID

Required

The device must have a unique device ID using the format required for its bus. For example, a PCI device must comply with PCI 2.1 and provide a Subsystem ID and Subsystem Vendor ID, as defined in Chapter 9, “PCI.”

Note: Multiple-monitor support allows Display class devices to be initialized independent of the system initialization process. For this reason, system-board and add-on display devices cannot use the VGA BIOS POST routine to populate the Subsystem Vendor ID because the device’s POST code might not be executed until later in the process, after device enumeration occurs. For system-board devices, the system BIOS should populate the Subsystem Vendor ID at power on. Add-on display adapters should provide a method for populating the Subsystem Vendor ID at the point when power is applied and the device is initialized to the state that is ready for POST.

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14.46. System supports conflict resolution, VGA compatibility, and extended registers

Required

When the end user changes or adds a graphics adapter to the system, setting resource assignments must not require changing jumpers or switches on either the card or the system board. The system must be able to automatically relocate the resources used by a graphics adapter on the system board when a graphics adapter expansion card is added to the system. In the event of an irreconcilable conflict with other devices on the system, the system must be able to disable one of the adapters in order to prevent the system from stalling.

The system must support the VGA graphics standard for application compatibility and for the Windows clean-boot error-recovery process. If a VGA BIOS exists on the graphics adapter, it must be able to configure its base address to C0000h and one alternate address, at a minimum, to prevent conflicts.

Extended resources are additional I/O ports, direct-access frame buffers, or data transfer areas on a graphics adapter that use more resources than does standard VGA. The Windows configuration manager must be able to map the resources to avoid conflicts with other system devices. At least one alternate configuration must be provided for each non-VGA display resource in the event of conflict during the IPL boot.

The software drivers and VGA BIOS (if used) must be able to use alternate configuration register addresses. The system must be able to dynamically disable or relocate VGA resources from C0000h. It must also be possible to re-enable these resources upon system reboot or reset.

For additional related requirements for multiple monitor support, see “Multiple-Adapter and Multiple-Monitor Support” earlier in this chapter.

BIOS and Option ROM Requirements for Graphics Adapters

The requirements in this section relate to BIOS support for graphics adapters.

14.47. Chips support linear packed-pixel frame buffer, relocatable above 16 MB

Required

Note: For DirectDraw, the graphics adapter’s chip set must support linear access to the frame buffer by the host.

Windows operating systems are optimized for a graphics adapter with a packed-pixel frame buffer at all supported resolutions. Memory-mapped packed-pixel frame buffers also provide a fast and simple interface between Windows and the graphics adapter. The Windows DIB engine provides a very fast display by writing directly to packed-pixel frame buffers; this architecture requires that the hardware developer write only a small, simple device driver.

For optimized support with Windows, a linear packed-pixel frame buffer is required over a bank-switched frame buffer. Use 32-bit addresses to allow the linear frame buffer to be placed above the 16-MB ISA boundary, which enables a system to be populated with large amounts of RAM.

If memory or other resources conflict with the frame buffer being mapped into a linear address space, the page frame address can be used with minimal degradation of performance.

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14.48. Option ROM supports DDC2B

Required

This requirement does not apply for systems that use RISC-based processors.

The option ROM for the graphics adapter must meet current DDC2B host requirements documented in *Display Data Channel Standard, Version 3.0*, Level 2B protocol (DDC2B), published by VESA. This standard defines the functions that support the data channel between the graphics adapter and a DDC-compliant monitor.

14.49. BIOS setup utility provides option to force use of system-board graphics

Recommended

The OEM should provide an option in the system BIOS setup utility to force the system-board graphics device to be used, ignoring and disabling any PCI graphics adapters. This option would ensure that a user with a PCI hot-docking system is always able to undock because the VGA device will be in the mobile unit.

14.50. BIOS supports large frame buffers for graphics adapters

Required

The BIOS must support large frame-buffer graphics adapters that have up to 256 MB of frame buffers.

AGP Requirements

This section defines the requirements for systems that implement AGP.

AGP technology allows textures to be stored in system memory, enabling larger, detailed texture maps in consumer applications. Effective AGP implementations can eliminate the need for a local memory texture cache, as defined in requirement 14.8, “Screen resolution and local memory capacity meet PC 99 minimum requirements.”

14.51. AGP meets PC 99 implementation guidelines

Required

The following is required for implementing AGP:

- Comply with the PCI Bus Power Management Interface Specification, Revision 1.0 or later, including the Configuration Space registers and the device state (Dx) definitions
- Comply with PCI 2.1 software interface layers, including the PC 99 requirements for Subsystem ID and Subsystem Vendor ID
- Comply with Accelerated Graphics Port Interface Specification, Revision 1.0 or later. This means the card has an AGP capability pointer with a working AGP capability structure that has the following characteristics:
  - A minimum request-queue depth of 1 DWORD (RQ value of 0)
  - A workable AGP_ENABLE
  - A minimum speed of 2x, system implementation of GART, and support for non-local video memory are required for all system types except mobile PCs

Mobile PC Note

For mobile PCs, 1x is an acceptable speed and GART is recommended, rather than required. For more information, see Chapter 6, “Mobile PC 99.”

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Requirements for PCI Graphics Adapters

The requirements in this section apply for graphics adapters that use the PCI bus.

14.52. PCI graphics device supports IRQ and correctly populates PCI BARs

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Required	*Recommended*	*Recommended*	*Required*	*Required*

Proper IRQ support is needed for optimal support of video playback. The display driver queries the actual device to find its register locations and so on. The PCI base address registers (BARs) must be populated correctly for this information to be correct in the registry.

On adapters that do not support an IRQ, the Interrupt Pin Register (3Dh) should be zero (0).

14.53. PCI system-board graphics device is not hidden from Plug and Play enumeration

Required for all system types

The system-board device must disable the PCI device rather than hiding it. Hiding the system-board graphics adapter from the PCI bus when another graphics adapter is detected in the system causes problems for supporting multi-monitor capabilities.

Power Management for Graphics Adapters

This section summarizes the specific power management requirements for graphics adapters.

14.54. Graphics adapter complies with device class power management reference specification

Required

The *Display Device Class Power Management Reference Specification, Version 1.0* or later, provides definitions of the OnNow device power states (D0–D3) for display and graphics devices. The specification also covers device functionality expected in each power state and the possible wake-up event definitions for the class, if any. Power states D0 and D3 are required; D1 and D2 are optional for graphics adapters.

14.55. Graphics adapter complies with VBE/Core 2.0 extensions for power management

Required

The *VESA BIOS Extension Standard/Core Functions 2.0* (VBE/Core 2.0) specification defines extensions to VGA ROM BIOS services for power management.

Device Drivers and Installation for Graphics Adapters

This section summarizes the requirements for graphics adapters. The specifications in this section are required for all PC 99 systems.

For additional driver-related requirements for multiple-monitor support, see “Multiple-Adapter and Multiple-Monitor Support” earlier in this chapter.

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Note: Software provided with graphics adapters designed for use with Windows NT 5.0 must comply with the requirements defined in the drivers section of the Windows NT 5.0 DDK.

This information will be available in the Beta 2 version of the DDK, expected later this year, in the "Compatibility Testing Requirements for Display and Video Miniport Drivers.

14.56. Device drivers and installation meet PC 99 requirements

Required

The manufacturer does not need to supply a driver for a device if the device passes PC 99 compliance testing using a driver provided with the operating system. If the manufacturer supplies a driver, it must comply with requirement 3.16, "Device driver and installation meet PC 99 requirements." The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

Note: For Windows 98, the display driver (.DRV) component loaded and called by the operating system is a Win16 module.

14.57. Driver does not bypass any Microsoft-provided system components

Required

The driver must not bypass or patch any Microsoft-provided system components. For Windows, this includes Gdi.exe, Kernel.exe, User.exe, Dibeng.dll, Mmsystem.dll, Ddraw.dll, D3d*.dll, and so on.

For Windows NT, this requirement applies for all files normally installed in the System32 directory. These files include, but are not limited to, Win32k.sys, Ntoskrnl.exe, Gdi32.dll, User32.dll, and Mcdsrv32.dll.

14.58. Applications provided with device meet requirements for Win32-based applications

Required

Any Windows-based applications provided with the device must meet Microsoft requirements for software compatibility as defined in the Microsoft Platform SDK.

14.59. Driver supports dynamic color bit-depth change

Required

The graphics adapter must operate properly and must not fail when asked by the operating system to change the color depth.

Graphics Adapters References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Accelerated Graphics Port Interface Specification, Revision 1.0 or later
http://developer.intel.com

ATSC DTV Specification
http://www.atsc.org

Design guidelines for DirectX, multiple-monitor/multiple-adapter support, and white paper on DirectDraw VPE and kernel-mode video transport
http://www.microsoft.com/hwdev/devdes/vpe.htm

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Display Data Channel Standard, Version 3.0
Display Device Class Power Management Reference Specification Display Version 1.0 or later
http://www.microsoft.com/hwdev/onnow.htm

Microsoft Windows 95 DDK, Windows 98 DDK, Windows NT 5.0 DDK, and DirectX 5.0 DDK
MSDN Professional membership

PCI Local Bus Specification, Revision 2.1 (PCI 2.1)
PCI Bus Power Management Interface Specification, Revision 1.0
Phone: (800) 433-5177
http://www.pcisig.com

VESA BIOS Extension Standard/Core Functions 2.0 (VBE/Core 2.0)
VESA and Industry Standards and Guidelines for Computer Display Monitor Timing
http://www.vesa.org

Checklist for Graphics Adapters

If a recommended feature is implemented, it must meet the requirements for that feature as defined in this document.

Consumer	Office	Mobile	Workstation	Entertainment
14.1. Graphics adapter uses PCI, AGP, or another high-speed bus				
Required for all system types				
14.2. System provides hardware-accelerated 3-D graphics				
Required	*Recommended*	*Recommended*	*Required*	*Required*
14.3. System uses WC with higher-performance processors				
Required for all system types				
14.4. Primary graphics adapter works normally with default VGA mode driver				
Required for all system types				
14.5. Adapter and driver support multiple adapters and multiple monitors				
Required	*Required*	*Recommended*	*Required*	*Required*
14.6. Adapter supports television output if system does not include large-screen monitor				
Recommended for all system types				
14.7. Adapter meets PC 99 general device requirements				
Required for all system types				
14.8. Screen resolution and local memory capacity meet PC 99 minimum requirements				
Required for all system types, with exceptions for mobile PCs				
14.9. Adapter meets VESA specifications for ergonomic timing rates				
Required for all system types, with exceptions for mobile PCs and flat panel desktop displays				
14.10. All supported color depths are enumerated				
Required for all system types				
14.11. Graphics operations use relocatable registers only				
Required for all system types				
14.12. Adapter supports downloadable RAMDAC entries for integrated color management				
Required for all system types				
14.13. Adapter supports DDC monitor detection				
Required for all system types, with exceptions for mobile PCs				
14.14. Hardware supports video overlay surface with scaling				
Required for systems that support TV or DVD video playback, with exceptions for mobile PCs				
14.15. Hardware supports VGA destination color keying for video rectangle				
Required for systems that support TV or DVD video playback				

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14.16. Hardware supports alpha blending of graphics and video
Required for systems that support TV of DVD video playback

14.17. Video port meets PC 99 specifications if present on graphics adapter
Required

14.18. Hardware supports MPEG-2 motion compensation acceleration
Recommended

14.19. Hardware supports scanning at the same frequency as the incoming video
Recommended Recommended Recommended Recommended Required

14.20. Extended resources can be dynamically relocated after system boot
Required

14.21. VGA resources can be disabled by software
Required

14.22. Frame buffer can be accessed directly by applications
Required for all system types

14.23. Adapter and driver support linear-mapped, low-resolution modes
Required for all system types

14.24. Hardware supports transparent blter
Required for all system types

14.25. Hardware provides support to prevent tearing
Required for all system types

14.26. Hardware supports programmable blter stride
Required for all system types

14.27. Hardware supports PC 99-required RGB rasterization
Required for all system types, with exceptions for mobile PCs

14.28. Hardware supports recommended RGB rasterization features
Recommended for all system types, with exceptions for mobile PCs

14.29. Hardware supports multi-texturing
Recommended Recommended Recommended Required Required

14.30. Hardware supports texture formats
Required for all system types, with exceptions for mobile PCs

14.31. Hardware complies with texture size limitations
Required Recommended Recommended Required Required

14.32. Hardware supports destination RGB alpha blending
Recommended for all system types

14.33. Hardware supports Z comparison modes and Direct3D-compatible formats
Recommended Recommended Recommended Required Required

14.34. Hardware meets PC 99 3-D accelerator performance requirements
Recommended Recommended Recommended Required Required

14.35. Adapter supports both NTSC and PAL output
Recommended for all system types

14.36. Default boot mode supports appropriate locale
Required for all system types

14.37. Adapter supports underscan scaling
Required Recommended Recommended Recommended Required

14.38. Adapter supports flicker filter
Required for all system types, with exceptions for mobile PCs

14.39. Adapter provides proper termination
Required

14.40. Adapter supports composite video and S-Video connectors
Recommended Recommended Recommended Recommended Required

14.41. Adapter with television output supports both VGA and television output
Required for all system types

14.42. Software supports positioning
Required Recommended Recommended Recommended Required

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14.43. Software supports detection of television connection
Required Recommended Recommended Recommended Required

14.44. Analog video outputs, such as NTSC, have copy protection on DVD-enabled platforms
Required for all system types

14.45. Each device has a Plug and Play device ID
Required

14.46. System supports conflict resolution, VGA compatibility, and extended registers
Required

14.47. Chips support linear packed-pixel frame buffer, relocatable above 16 MB
Required

14.48. Option ROM supports DDC2B
Required

14.49. BIOS setup utility provides option to force use of system-board graphics
Recommended

14.50. BIOS supports large frame buffers for graphics adapters
Required

14.51. AGP meets PC 99 implementation guidelines
Required

14.52. PCI graphics device supports IRQ and correctly populates PCI BARs
Required Recommended Recommended Required Required

14.53. PCI system-board graphics device is not hidden from Plug and Play enumeration
Required for all system types

14.54. Graphics adapter complies with device class power management reference specification
Required

14.55. Graphics adapter complies with VBE/Core 2.0 extensions for power management
Required

14.56. Device drivers and installation meet PC 99 requirements
Required

14.57. Driver does not bypass any Microsoft-provided system components
Required

14.58. Applications provided with device meet requirements for Win32-based applications
Required

14.59. Driver supports dynamic color bit-depth change
Required

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